# FORENSIC-MEDICINE DIAGNOSIS OF THE DROWNING (SUBMERSION) IN FRESH AND SEA WATER

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The forensic medicine shows an interest in the drowning, mainly because it is the object of the investigating authorities when they establish the real reason for death: drowning, death in water or dead body in water. The differentiative diagnosis of a drowning in fresh and sea water is of medicocriminative importance. Until now medical science has no reliable morphological and laboratory data to diagnose precisely the drowning in both waters. Therefore, the object of our study is to investigate the pathomorphological changes in drowned people and their blood and organs' indexes (parameters), so that the diagnosis of the drowning and its differentiation, concerning fresh and sea water, is improved and precise.

## Material and methods

The study covers: 1) Forensic-medicine investigation of 266 drowned people (240 — in sea water and 26 — in fresh water: rivers, lakes, etc.); 2) Experimental investigation of 192 animals (guinea pigs, rabbits), drowned under various conditions: quickly, slowly, at different water temperature.

The following methods were applied: 1) Statistical: variational analysis, maximum deviation of the mean value, T-criterion of the established differences at thrust-internal $p<0.05$, etc. 2) Morphological methods: a) Macroscopic investigation of the changes of drowned people and experimental animals, including Moro and Sveshtnikov, lungs' volume measurement, etc.; b) histological — hemalaum-eosin, staining of collagen fibres after van Gieson and Krutchai, staining of elastic fibres after Weiger, staining of argirophile substances after Gomori.; c) histochemical glycogen-detection by PAS-reaction after McManus and Best, acid mucopolysaccharides with alzian-blue, reaction of Hans Selie for establishment of fuxinophile degeneration, reaction of Fögen and Brachee for establishment DNA- and RNA-changes: Luminescent-determination of secondary luminescence of the lungs after a fluorochromes at different pH of the solution and different saline contents. 3) Laboratory methods: a). determination of bloodindexes and their changes (chloride, leucocytes, Hb, haematocrite, erythrocytes, relative weight of blood from chambers; b) determination of diatomite content of the abdominal organs of drowned people and experimental animals (in fresh and sea water).

## Results and discussion

External features (signs): most often — facial cyanosis (69.17%), spotted haemorrhages on the conjunctiva (65.78%) and small-bubbled foam in nose and mouth (37.71%). The foam (after drowning) was very characteristic (small-bubbled, dense, with side-particles in it). The pale skin, cutis anserinus, conjunctival oedema, macerative changes, etc. were a result either of the total hypoxia or of the stay in water.

Internal examination: acute pulmonal swelling (82.70%) with rounded edges, costal impression on the lung surface, covered heart. The swelling was less expressed in people drowned in sea water. The outer and cut surface of the lungs (78.94%) was versicoloured (shagreen). The "haemolytical garland" was established exclusively after fresh water drowning: the uncut lungs were placed on a white surface. The lungs' volume of all drowned people and animals was increased (fresh water — more), while their specific weight was considerably higher after sea water drowning (submersion). The macules (marks) of Tardeau were found in 72.08% of the drowned in sea water and 57.69% — in fresh water, while Razkazov—Lukomski—Palltauf macules were more often findings after fresh water submersion (73.07%) compared to that after sea water (35.66%). The dryish appearance of the section-surface of the lungs (very often reported) was found only in 22.56% of our cases. The oedematic forms of emphysema (emphysema hydroaerico — 60.89%) were predominant after sea water drowning, while the aero-form of emphysema prevailed after fresh water submersion. Our invesigations suggested that no clear forms were available and there were predominant forms of emphysema.

Liquid content in the stomach was established in 71.42% of our cases and 43.98% had liquid content even in the intestines. Alien (side) particles (sand, seaweeds, etc.) were found in 52.25% of the drowned, i. e. in their stomachs. The free stomach liquid (Moro's sign) is averagely with 4.47 ml more in the drowned than in the controls ($p<0.05$). The polyhaemia (plethora) of the liver and its enlarged weight was established in all cases of typical submersion and it was $1920\pm68$ in healthy adults compared to $1527\pm79$ in the controls. Oedema of the gall-bladder and hepatoduodental duct was detected in 86.66% as a result of the hydraemia and blood-stasis; the oedema did not disappear even in the first stage (initial degree) of the corpse-decay. The spleen was anaemic in 62.67% of the cases (Sabinski—Orahovatz sign). The symptom of Sveshtnikov (liquid in the sinus of os sphenoidalis) was positive in 87.25% of the drowned and alien-particles were detected in 70.58% (mainly diatomites in the liquid).

Microscope investigation of the lungs: 4 zones: a) acute emphysema with thorn interalveolar septa, b) moderate swell of alveoles with oedematic liquid and white blood cells, c) atelectasic zones, d) zones of normal, unchanged pulmonal tissue. The emphysema after submersion differed to that of the pulmonary diseases by the lack of atrophy of the elastic tissue, the heavy circulatory disorders and no myocardial changes. The alveoles were slightly swelled after sea water drowning, with a present reserve roughness (folding) and they had thorn interalveolar septa, compared to those of fresh water drowned people and animals. The oedematic liquid was pale, unequally coloured and with a honeycomb-form. The erythrocytes were

preserved in form and colour (sea water submersion). Except them, desquamated alveolar cells, histeocytes and macrophages were also found in the alveolar cavity, forming the characteristics of a "catharal alveolistis".

Considerable differences of the luminescence of 5 (Acridin gelb, Brillant phosphin 0, Coriphosphin, Auryzin 2gNx, Acridin orange) out of all 10 applied fluorochromes were established in the investigated (by luminescence) lungs of experimental animals. It depended on the saline content of the water: sea water drowned animals were more demonstrative than fresh water drowned.

Certain myocardial disorders were founded as a result of the hypoxia and electrolite changes. Part of them were due to the acute blood-stream changes, others — to necrobiotical effects. Sudden vessels' plethora was detected (especially the small local haemorrhages, acute plasmatic soaking in the intima of various arteries, perivascular oedema, fuxinophileness and homogeneousness, disappeared striation and fragmentation). The fuxinophile degeneration was better expressed after sea water submersion; the same was established with the experimental animals drowned in sea water or slowly drowned in either water. Decrease and disappearance of the granular glycogen was founded as a result of the anaerobic glycogenolysis. The degree of glycogen disappearance was due to the duration of hypoxia — better expressed after sea water drowning and slowly drowned animals in both waters.

The method of blood-chloride determination (from left and right heart chamber) was considered to be most appropriate of all laboratory investi-

Table 1

**Characteristic aud uncharacteristic signs of submersion**

| Characteristic signs | Uncharacteristic signs |
|---|---|
| 1. Small-bubbled rough foam in nose and mouth | 1. Facial cyanoais |
| 2. Acute alveolar emphysema of the lungs with shagreen section-surface and macuies of Razkazov-Lukomski-Palltauf | 2. Conjunctival oedema, anserine skin macerative changes |
| 5. Liquid in the stomach and intestines with alien-particles (sands, diatomites, etc.) | 3. Spotted haemorrhages on the mucous surface (Tardeau) |
| 4. Liquid in the sinus of the sphenoidal bone (Symptom of Sveshtnikov) | 4. Liquified blood, abundantly expressed postmortal macules and blood-stasis of the organs |
| 5, Oedema of the gall-bladder and hepatoduodenal duct | 5. Brain oedema and pulmonal oedema |
| 6. Diatomites in blood and organs (abdominal) | 6. Plethoral spleen |
| 7. Changes ol the chloride level and elements in blood of both heart-chambers | 7. Enlarged liver (in weight) |
| 8. Changes of the secondary luminescence of the lungs | 8. Pleural and abdominal transudate |

gations: sea-water submersion — higher in left-chamber blood, fresh water submersion — higher in right-chamber blood (both differences were statistically reliable, $p<0.05$). The method could be successfully applied with corpses in initial decay, while the rest laboratory investigations of the blood (relative weight, Hb, leucocytes, erythrocytes, haematocrit) were changeable in decayed corpses, therefore, they could be hardly applied in the routine forensic medicine practice.

The carried investigations support the importance of the diatomite-content determination in the abdominal organs after drowning, especially if the diatomite-characteristics of the pool of drowning is known. Diatomites were found in the lungs of 76.54% of our cases, including all experimental animals drowned in diatomite-water; in the kidneys — 72.47%, liver — 72.48%, blood — 65.70%, heart — 66.66% and bone-marrow — 60.00%. No diatomites in the lungs revealed but also diatomites in the rest organs. Most often diatomites in sea water drowned were: Cyclotella caspia, Thalassionema nitzchioides, Sceletonema costatum, Chaetocerus similis, while in fresh water drowned they were: Pinnularia, Diatoma, Navicula, Synedra. No diatomites were detected in 20 controls (traumatic and hung). No diatomites were detected even in animals drunk water with diatomites, also animals after their death put in water with diatomites.

It is obvious that many features and signs are established after submersion: some of them are characteristic for drowning-death, others are a result of total hypoxia and stay in water (Table 1). Certain differences of

Table 2

**Differential-diagnostic features of fresh and ses water drowning**

| Sea water | Fresh water |
|---|---|
| 1. Predominant hydroaeric form of the acute emphysema with Tardeaumacules | 1. Predominant aeric form of the acute emphysema and Razkazov-Lukomski-Palltauf macules |
| 2. Expressed circulatory disorders of lungs and heart | 2. Haemolytic garland round the lungs |
| 3. Higher level of chlorides and elements in blood of the left heart-chamber | 3. Liquifying of the blood of the left heart-chamber (low number of erythrocytes, Hb, chlorides) |
| 4. Characteristic sea diatomites in blood and abdominal organs | 4. Poor fuxinophile myocardial degeneration |
| 5. Well developed fuxinophile myocardial degeneration | 5. Incomplete disappearance of glycogen in myocardium |
| 6. Complete disappearance of glycogen in myocardium | 6. Poor secondary luminescence of lung tissue |
| 7. Expressed secondary luminescence of the lung tissue | |

the data are found in the morphological and laboratory studies of the drowned in both waters (Table 2), whose details allow the differentiative diagnosis of the 2 types of drowning.

## Conclusions

The following indexes (signs) are predominant after sea water submersion: hydroaeric form of the acute emphysema with spotted haemorrhages of Tardeau, better expressed circulary disorders of the lungs and heart, well developed fuxinophile degeneration and more complete disappearance of the glycogen in the myocardium, intensive secondary luminescence of the fluorochromated lungs, increased chloride content in blood and left heart chamber, characteristic sea diatomites.

In order to determine whether drowning is sea water or fresh water drowning, we need: complex investigations, comparison of morphological and laboratory data, considering the conditions and environment where the drowned corpse is found.

## СУДЕБНО-МЕДИЦИНСКОЙ ДИАГНОЗ УТОПЛЕНИЯ В ПРЕСНОЙ И МОРСКОЙ ВОДЕ

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РЕЗЮМЕ

В работе приводятся данные результатов морфологических и лабораторных исследований 266 утопленников и 192 подопытных животных (морских свинок, крыс и кроликов, утопленных при различных условиях). Как характерные и постоянные устанавливаются следующие признаки: мелко-пузырчатая пена через нос и через рот, острый альвеолярный энфизем с кровоизлияниями Тардьо и Расказова—Лукомского—Пальтауфа, жидкость в полости сфеноидальной кости, в желудке и верхней части тонкого кишечника, отек желчного пузыря, диатомеи во внутренних органах, изменения хлоридов и показателей крови обеих половин сердца, некробиотические изменения сердечной мышцы, исчезновение гранулярного гликогена, изменения вторичной люминесценции легочной ткани.

При утоплении в морской воде преобладают: гидро-аэрическая форма острого энфизема и кровоизлияния Тардьо, выраженные циркуляриторные расстройства в легких и сердечной мышце, повышенный уровень хлоридов и фарменных элементов крови в левой половине сердца, характерные морские диатомеи в крови и во внутренних органах, хорошо выраженная фуксинофильная дегенерация сердечной мышцы, более полное исчезновение гликогена, меньший объем и более высокий специфический вес легких и ярче выраженная вторичная люминесценция легочной ткани.